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A numerical approach of two-phase non-Darcy flow in heterogeneous porous media:

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Significant inertial effects are observed for many applications such as flow in the near-wellbore region, in very permeable reservoirs or in packed-bed reactors. In these cases, the classical description of two-phase flow in porous media by the generalized Darcy's law is no longer valid. Due to the lack of a formalized theoretical model confirmed experimentally, our study is based on a generalized Darcy-Forchheimer approach for modelling two-phase incompressible inertial flow in porous media. Using a finite volume formulation, an IMPES (IMplicit for Pressures, EXplicit for Saturations) scheme and a Fixed Point method for the treatment of non-linearities caused by inertia, a 3D numerical tool has been developed.

For 1D flow in a homogeneous porous medium, comparison of saturation profiles obtained numerically at different times to those obtained semi-analytically using an “Inertial Buckley-Leverett model” allows a validation of the tool. The influence of inertial effects on the saturation profiles and therefore on the breakthrough curves for homogeneous media is analysed for different Reynolds numbers, thus emphasizing the necessity of taking into account this additional energy loss when necessary. For 1D heterogeneous configurations, a thorough analysis of the saturation fronts as well as the saturation jumps at the interface between two media of contrasted properties highlights the influence of inertial effects for different Reynolds and capillary numbers. In 2D heterogeneous configurations, saturation distributions are strongly affected by inertial effects. In particular, capillary trapping of the displaced fluid observed for the Darcy regime in certain regions can completely disappear when inertial effects become dominant.